Review article The Management of difficult intubation in children

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Summary

This article looks at the current techniques and equipment recommended for the management of the difficult intubation scenario in pediatric practice. We discuss the general considerations including preoperative preparation, the preferred anesthetic technique and the use of both rigid laryngoscopic and fiberoptic techniques for intubation. The unanticipated scenario is also discussed.

Keywords: paediatric; anaesthesia; difficult airway; difficult intubation; failed intubation; fibreoptic intubation; Laryngeal mask

Introduction

Generally, but not always, in pediatric practice, the management of the difficult intubation scenario is a well predicted, well planned and hopefully well executed procedure. However, undoubtedly, there will be occasions when difficulty with either airway management (difficulty or inability to ventilate the patient or maintain an airway) and/or with endotracheal intubation is unexpected. In this article we will look at the management of predicted, elective difficult airway management and difficult intubation procedures. We will also look at the management of the unanticipated situation where airway or ventilation difficulty arises in addition to difficult endotracheal intubation.

Management of the anticipated difficult intubation scenario

Preoperative planning

General issues

If difficulty is anticipated with airway management and endotracheal intubation there are a number of

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parents and the child if appropriate. This should be performed well in advance at the preoperative visit. Firstly, the relative benefit of any planned surgery must be weighed against the possible risks of the anesthetic management. If there is any doubt surrounding either the timing of the surgery or indeed the need for surgery, a full discussion should take place with carers, child, surgeon and anesthetist to plan the way forward. Next, the anesthesia plan should be discussed. Both

issues which need to be discussed in detail with the

Next, the anesthesia plan should be discussed. Both child and carers should be aware of the choice of anesthetic technique and the reason for this choice. If there is a possibility of a tracheostomy, this should be discussed. This may be required either in the emergency situation or may be necessary as a planned procedure after the airway has been secured.

There is always the question of how far it is reasonable for the anesthetist to go in the difficult airway scenario, should things not go as planned. Does the anesthetist continue with attempts to intubate at all costs or after multiple failed attempts should the child be woken up. These issues will, of course, be determined by the individual situation and by the urgency of the surgery. The more urgent or necessary the surgery, the more important the discussion of a possible emergency tracheostomy becomes. A bottom line plan or alternative plan of action should be thought through and if possible, discussed preoperatively. All discussions and plans should be clearly documented (1).

Premedication

Many anesthetists feel that the use of sedative premedication in the child with an obstructed or potentially obstructed airway is contraindicated (2). There remains, however, the real problem of a terrified child with a potentially difficult airway in the anesthetic room. He or she is crying and producing lots of secretions, and it may prove difficult to get near the child simply to place monitoring and then to place an intravenous canula or do an inhalational induction. The ability to induce anesthesia in a smooth and calm atmosphere with full monitoring applied is a priority and adds considerable safety to the process. To facilitate this we would recommend a small sedative premedicant such as oral midazolam in a dose of $0.3-0.5 \text{ mg} \cdot \text{kg}^{-1}$. However, the individual circumstances of every case must be considered.

Antimuscarinics, such as atropine and glycopyrronium are useful to dry secretions and support the heart rate during induction. The antisialogogue property remains the main property for their use today. Atropine can be used orally or intramuscularly. The oral dose is $30-40 \ \mu g \cdot k g^{-1}$, and peak effect takes up to 90 min. If given intramuscularly in a dose of $20 \ \mu g \cdot k g^{-1}$, peak effect takes place after 25 min (3).

Choice of anesthetic technique

The principle of managing the difficult airway in this age group is to maintain spontaneous ventilation until the airway is secure (4,5). An awake technique relies on good patient cooperation and therefore, in the pediatric population is not often practised. Awake intubation in the neonatal period remains a possibility using rigid and fiberoptic scopes (6). Johnson and Sims describe a nice technique in an infant with Goldenhar syndrome using topical local anesthesia and railroading an endotracheal tube (ETT) over a small fiberoptic bronchoscope through a laryngeal mask airway (LMA). This technique has recently been reported again for use in neonates with upper airway obstruction (7). A spontaneous ventilation technique retains some muscle tone in the upper airway and allows the anesthetist time to use alternative equipment such as flexible fiberoptic scopes to gain a view of the structures and intubate the patient. Use of a muscle relaxant to take over ventilation in the difficult airway can potentially result in difficulty in ventilation and hypoxia in a patient who cannot be intubated. This scenario can rapidly degenerate into the 'Can't ventilate, Can't intubate scenario'. It cannot be emphasized enough that adequate time is an important factor for success in these situations and a spontaneous ventilation technique is recommended.

The use of an inhalational technique is favored in pediatric practice (8). It is our practice to use a gaseous induction with sevoflurane in 100% oxygen. The child is fully monitored and following loss of consciousness an intravenous canula is placed. The child is then deepened to a plane where laryngoscopy can take place.

In those children who flatly refuse to have a gaseous induction or indeed those children in whom a facemask does not fit there are a couple of options (9,10). The use of an intravenous induction agent in very small dosages can allow loss of consciousness but preserve spontaneous respiration. Propofol in a dosage of 0.5–1 mg·kg⁻¹ titrated slowly will achieve this end. Ketamine in a dosage of $1-2 \text{ mg} \cdot \text{kg}^{-1}$ again titrated carefully will also work. Following loss of consciousness with this technique the patient can then be deepened with sevoflurane until again an adequate plane of anesthesia has been achieved for laryngoscopy. Some pediatric anesthetists may favor a total intravenous technique for this situation. Whatever technique is chosen, the maintenance of spontaneous respiration is in our opinion critical to the safety and success of airway management.

Should the airway obstruct early, as is typical for the child with mucopolysaccharidoses, the child can be turned into the lateral position to allow the tongue to fall out of the mouth and vigorous jaw thrust applied (11,12). If this is insufficient, a soft nasal airway should be placed to clear the airway (13). The use of a nasal airway early in the induction can improve the airway allowing the anesthetist to avoid oral airways till later in the induction.

The aim, as previously stated, is to deepen the patient sufficiently until one can perform a laryn-

goscopy using at first conventional rigid laryngoscopes. If direct larygoscopy proves difficult and the view of the larynx poor, it is important to minimize the number of attempts, in case significant trauma and bleeding occur making subsequent attempts with alternative means more difficult or impossible. If intubation is not possible with conventional equipment, i.e. with introducers or a gum elastic bougie, one must proceed with an alternative plan.

Golden rules for the anticipated difficult intubation scenario:

- Have all equipment to hand and check before patient is in the anesthetic room
- Get good assistance. This may be another experienced anesthetist
- Plan ahead, and have a 'bottom line plan' i.e. what to do if things don't go to plan. Wake up or proceed with a surgical airway

Equipment and techniques

Conventional rigid laryngoscopes

The choice of laryngoscope blade is of importance. Conventional laryngoscopy with a flat curved blade such as a Macintosh will often prove disappointing in a patient with any degree of micrognathia. This is because the normal sized tongue cannot be compressed adequately into the mandibular space to reveal the laryngeal structures. The posterior third of the tongue will usually obscure the view. This is a similar situation to the infant airway where the majority of the tongue is in the oral cavity to aid suckling, the mandible is relatively underdeveloped and the larynx is at a higher position than the older child or adult (14). The net result of these differences is a poor view with a curved rigid laryngoscope.

On the other hand, the use of a narrow low profile straight bladed laryngoscope in a 'paraglossal' manner can often overcome this problem (15). The blade is advanced in the space between the tongue and the lateral pharyngeal wall or tonsillar fossa. Video 1 and 2. Video 1 is intubation with a Miller blade in an infant in a Paraglossal manner. Video 2 is Laryngoscopy of a child with micrognathia using the Far lateral approach.) The straight axis is shorter and insertion of the ETT may be aided by a stylet or use of a gum elastic bougie. This approach is also called the retromolar approach, the Far lateral approach and the right molar approach (18,19). Logically,



Figure 1 Different sizes of Storz straight blade laryngoscopes.

therefore, in any situation of relative macroglossia, either in an infant or in a child with micrognathia, a straight blade laryngoscope should be first choice. Examples of good equipment to use would be the Miller blades or the ENT rigid Storz Laryngoscopes with light attachment (see Figure 1). The added light from a dedicated light source can make a big difference.

Video laryngoscopy with standard pediatric blades (Karl Storz, Tuttlingen, Germany) is a newly available technology with potential use for teaching but also in the difficult intubation scenario (20).Use of this system using the Miller 1 video laryngoscope has recently been reported in a neonate with Desbuquois syndrome (21). This child had a poor glottic view by direct laryngoscopy but a grade 1 view using video laryngoscopy. There are two devices currently available using this type of technology: the pediatric video laryngoscope (Storz), and the Glidescope (Verathon, Bothell, WA, USA). The literature is sparse at the moment on these devices. Initial



Figure 2

The Seward and Macintosh McCoy levering laryngoscopes showing the size of the levering tips and their maximum angle of leverage.

experience of the use of the Glidescope in five neonates has been published (22). However, we await more reports.

The McCoy levering laryngoscope is another option (23,24). The McCoy laryngoscope comes in pediatric sizes on a Seward blade (sizes 1 & 2) and on a Macintosh blade for adult practice (sizes 3 & 4). (see Figure 2) . The levering tip on the Macintosh blades is larger than that on the Seward blades and may not be suitable for small children. When the tip of the adult scope is placed in the vallecula and the lever activated the epiglottis and larynx may be taken out of view. (Video 3. The use of the Seward pediatric McCoy laryngoscope in a child.)

Supraglottic airways

The laryngeal mask airway

The LMA now has a central role in the management of the difficult pediatric airway (26). Although first developed as an airway which could free up the hands of the anesthetist it has proven to be much more (27,28). Firstly, it can be of use as an alternative to endotracheal intubation for short cases. It can be used as a rescue airway and can be used during a failed intubation scenario to maintain oxygenation and anesthesia. It can also be used most effectively as a conduit to facilitate fiberoptic intubation (26,29,30). The classic laryn-

geal mask airway (cLMA) was used on a group of 34 children with craniofacial and mucopolysaccharide disorders and the airway was either classed as good or adequate in all patients. In no patients did the LMA provide a poor airway (26). This data compares with normal patients who had a clear airway in 98% (31). In addition, the fiberoptic view was either full or partial in 54% with the rest having a view of the epiglottis within the lumen of the LMA. The laryngeal structures of all patients with some manipulation of the fiberscope could be visualized and therefore intubated fiberoptically if needed (26). This data in addition to the many case reports of the use of the cLMA in pediatric anesthetic practice make the cLMA essential to the safe management of the difficult pediatric airway.

Other supraglottic airways

Other potentially useful supraglottic airways include the Proseal LMA (PLMA), the cuffed oro-pharyngeal airway (COPA) and the i-Gel.

The PLMA is a modified LMA which has both an increased depth of bowl and a wedge shaped dorsal cuff to improve airway seal (32). It has an esophageal drain to reduce gastric distention during positive pressure ventilation. The device can be placed using either digital manipulation or using the supplied introducer (33). A gum elastic bougie may aid placement (34). This device may be the supraglottic airway of choice in older children with a full stomach (35,36). The device is available in sizes from 1.5 to 5 and has recently been studied in a wide range of children (37). Sanders et al. showed a high rate of success of the PLMA in all ages of children and sizes of the PLMA. Both success rates for their placement and gastric tube insertion were well over 90% on first attempt.

The i-gel is another single use supraglottic airway with a gel filled noninflatable cuff, introduced recently into anesthetic practice. It has gained a reputation for ease of insertion but to date the smallest available size is a size 3 which is suitable for small adults. There are some reports of its use for airway rescue in the adult literature (38).

The COPA is available in a variety of sizes and makes and have been used for airway maintenance and as a conduit for fiberoptic intubation (39–41).

There place is as yet uncertain but may be useful should the cLMA fail.

Fiberoptic intubation techniques in pediatric practice

Flexible fiberoptic bronchoscopes are available with or without a suction channel. Ultra-thin bronchoscopes without a suction channel have a diameter of 2.2-2.5 mm and are used generally as nasendoscopes by our ENT colleagues. They are useful devices in theatre and can be used for fiberoptic intubation in neonates and infants using a railroading technique and can also be used (if long enough) to check the position of double lumen tubes or bronchial blockers in thoracic anesthesia. Bronchoscopes with a suction channel have an outer diameter of anywhere from 2.8-4 mm and above. The smallest flexible bronchoscope with a suction channel (approx 2.8 mm) has a poorer optical quality than the 2.5 mm scope without the suction channel because the channel takes up considerable space at the expense of light and optical fibers. This should be taken into consideration when buying a small diameter fiberscope. All small diameter fiberscopes must be handled with extreme care to prevent damage as they are expensive to maintain and repair.

General requirements for fiberoptic intubation success:

- Maintenance of good oxygenation and deep inhalational anesthesia allowing the operator time to view airway structures
- Topical anesthesia of the airway
- Good planning and availability of all necessary equipment
- Skilled assistance, all briefed with the plan and backup plan
- Equipment for backup plan to hand and checked (e.g. cricithyroidotomy device and high pressure ventilating device)

Choice of route for fiberoptic intubation

Nasal

The nasal route is generally reserved for patients with tempero-mandibular joint problems and limited mouth opening, but this route may also be required for surgical access. Preparation of the nose is critical to success. Vasoconstriction can be achieved using a variety of agents such as pseudoephedrine, phenylephrine or oyxmetazoline but can also be achieved very effectively by the use of small amounts of 1 : 10 000 Adrenaline soaked onto a pack. Nasal bleeding caused either by the fiberoptic scope or tracheal tube can result in a failed intubation (42).

Maintenance of anesthesia can be achieved by a variety of techniques. A nasal airway in the other nostril connected to the breathing circuit or a specially designed endoscopy mask can be used (43). Topical anesthesia of the larynx is also critical to the success of the technique in a spontaneous ventilation fiberoptic intubation. This can be achieved by the injection of plain lidocaine $(3 \text{ mg} \cdot \text{kg}^{-1})$ directly down the suction channel of the fiberscope or via an epidural catheter that can be inserted down the suction channel and advanced onto the glottis.

The choice of ETT is another critical factor for success. If too large a tube is selected intubation will fail and the operator must withdraw the fiberscope and start again. ETTs may 'catch' on the arytenoid tissue at the glottis during railroading. A snugly fitting ETT on the fiberscope will help to prevent this, as will the use of a flexometallic tube. The use of a small cuffed ETT may the best choice for a 'tube over scope' technique. Their use remains controversial but in this scenario it is a perhaps a safer choice than repeated bronchoscopy to find the correct fitting uncuffed tube (44,45).

Oral

The oral route avoids potential nasal trauma but the angles to the larynx are more acute. Anesthesia can be maintained via a nasal airway or a specially adapted facemask. The LMA, however, is now the most commonly used device to maintain anesthesia and act as a conduit for oral fiberoptic intubation.

Fiberoptic intubation through a laryngeal mask airway

Blind intubation techniques via the LMA have been described in children with difficult airways (46,47). This technique is not reliable and has a potential for

trauma and should only be attempted if a bronchoscope is not available. When using a fiberscope the LMA is first inserted with the patient breathing spontaneously. Once the patient is in a deep enough plane of anesthesia, a fiberoptic bronchoscope is introduced into the LMA until a view of the cords is obtained. Topical lidocaine is then sprayed onto the larynx via the suction channel and the bronchoscope is driven into the trachea and the carina visualized. There are then a number of ways to accomplish tracheal intubation.

Railroading over the bronchoscope

A preloaded tracheal tube can be railroaded (i.e. loading the tracheal tube onto the bronchoscope and sliding it off directly into the trachea) over the bronchoscope through the LMA (48–51). This has been demonstrated in a wide range of age groups including part of the management of an EXIT procedure in a child with dysgnathia complex (52). The problem then encountered is how to remove the LMA and bronchoscope without dislodging the ETT. Various ways of achieving this have been suggested. Many techniques include the use of two connected ETTs joined either by wedging the two together (53), taping them together (48) or with an adapted femaleto-female connector (50). (see Figure 3) However, the railroading of an ETT through an LMA can be awkward to do and accidental dislodgement of the ETT is a possibility on removal of the LMA. Another possibility is the use of the overlength Croup tube made by Portex. These tubes will avoid the need to connect two tubes of different sizes to remove the LMA after intubation has been achieved (Personal communication, Dr Josef Holski).

Using a guidewire and airway exchange catheter

A long J-tipped guidewire can be inserted via the suction channel into the trachea and the fiberoptic scope carefully removed (54,55). If the fiberoptic scope is too big for the child's trachea, the scope can sit above the cords and the guidewire inserted through the cords under direct vision. (see Figure 4) Following removal of the bronchoscope a 'stiffening' device, such as the Cook airway exchange catheter (Cook UK Ltd, Letchworth, England), is then rail-



Figure 3

'Telescoping of the endotracheal tubes over a fiberoptic bronchoscope through the laryngeal mask.



Figure 4

Guidewire technique. An extra long J-tipped guidewire is seen coming through the suction channel of the bronchoscope.

roaded over the guidewire through the LMA. Once in place, the guidewire is removed and the position of the airway exchange catheter verified by capnography (55). Only when correct placement of the exchange catheter has been confirmed is the LMA removed. A tracheal tube can then be railroaded over the catheter. (see Figure 5) The advantages of this technique are that it can be used in children of



Figure 5

The Equipment for a through laryngeal mask airway intubation using a guidewire and Cook airway exchanger.

any age and after insertion of the stiffening device the choice of the tracheal tube is less critical as it can easily be changed. Video 4. Fiberoptic through LMA intubation using a guidewire.

Using an airway exchange catheter without a guidewire

An ultrathin fiberoptic bronchoscope is lubricated with saline and a Cook airway exchange catheter is fitted over it (57). The loaded bronchoscope is passed through the LMA and into the larynx and the airway exchange catheter advanced under direct vision into the trachea. The LMA is then removed and a tracheal tube railroaded over the catheter into the trachea. This may be preferable to preloading an ETT as the airway exchange catheter will pass more easily into the trachea.

Other techniques

The Bullard rigid laryngoscope is a fiberoptic laryngoscope with a 90 degree bend to assist good visualization of the larynx. The pediatric size of this scope is popular amongst some pediatric anesthetists for the intubation of infants with mandibular hypoplasia (1,4). An intubating stylet or bougie is usually required to complete intubation.

A Rigid bronchoscope can be use to railroad an ETT in a difficult airway situation. A small Hopkin's Rod bronchoscope can mount a small ETT (without connector) (see Figure 6). This is a particularly good technique when upper airway pathology is present





A 2-mm Hopkin's rod bronchoscope is loaded with a small endotracheal tube without connector.

such as supraglottic cysts or pathology on the tongue base. (Video 5. Intubation of a difficult airway using hopkin's rod technique).

The pediatric Bonfils fiberscope is another possibility. The Bonfils intubation fiberscope (Karl Storz GmbH, Tuttlingen, Germany) is a rigid bronchoscope with a curved tip (40 degrees). A 3.5-mmtracheal tube can be railroaded over this device. Bein *et al.* recently evaluated this device in pediatric practice and found it difficult to use. They report a high failure rate and increased intubation time (59). They did, however, use the device alone without using a conventional laryngoscope. It may be that the use of conventional laryngoscopy would significantly improve this technique.

The unanticipated difficult intubation scenario

Problems associated with endotracheal intubation can cause significant soft tissue trauma and swelling and are the major cause of hypoxemic anesthetic deaths and brain damage due to inadequate ventilation (60,61). A comparison of pediatric and adult anesthesia closed malpractice claims revealed that, in the authors' opinion, of the pediatric claims that were due to inadequate ventilation, 89% could have been prevented (62).

Unanticipated difficult intubation does occur rarely after induction of anesthesia in a child. If the patient is breathing spontaneously and has a clear Failed intubation, increasing hypoxaemia and difficult ventilation in the paralysed anaesthetised patient: Rescue techniques for the "can't intubate, can't ventilate" situation

failed intubation and difficult ventilation (other than laryngospasm)



Difficult Airway Society guidelines Flow-chart 2004 (use with DAS guidelines paper)

Figure 7

Management of unanticipated difficult tracheal intubation – during routine induction of anesthesia in an adult patient [source: Henderson et al.].

airway it is reasonable to proceed with the patient breathing spontaneously and follow advice for a predicted difficult intubation. If the child has been paralysed and again proves difficult to intubate but easy to ventilate the techniques for the anticipated difficult intubation can be utilized.

The situation that we all fear is the difficult ventilation, difficult intubation scenario after paralysis in the routine or emergency situation. If this should occur following a Rapid Sequence Induction then attempts should be made to awaken the child whilst maintaining oxygenation. If a longer acting muscle relaxant has been given the principles of management are again to maintain oxygenation and ventilation by the best means possible.

Techniques for maintaining ventilation

Two operator mask ventilation

This can provide effective temporary ventilation until the airway is secured or the patient awakened (4). One person holds the mask with both hands and another squeezes the bag of the circuit. Another may be required to perform a jaw thrust.

Laryngeal mask airway

The LMA is an excellent device for this situation. It can be used as an alternative to endotracheal intubation in the difficult intubation scenario but is very useful in the difficult airway/difficult intubation scenario (26,29,30,63).

Guidelines and protocols

Although, this situation may be relatively uncommon there is a need to develop clear, simple guidelines that can easily be followed in the emergency situation. Difficult airway guidelines exist in many different countries for the management of the adult patient, but as yet there is only one pediatric guideline (2). There does remain, however, a need in pediatric practice for a clear and simple guideline in the model of the Difficult Airway Society document for adult patients of 2004. This document outlines a series of flow charts with back up plans as the authors rightly argue that no one single technique is always successful. They outline several principles of management that can equally be applied to pediatric practice. (see Figure 7).

General principles of management:

- Maintenance of oxygenation and ventilation are paramount
- Attempts at rigid laryngoscopy should be performed in optimal conditions
- Multiple and prolonged attempts at laryngoscopy are associated with morbidity and will not be fully apparent until until fiberoptic examination or extubation. Therefore, limit the number of attempts to four
- Blind techniques have a failure rate and are potentially traumatic
- Awaken patient and postpone surgery if possible
- In the failed intubation, increasing hypoxaemia and difficult ventilation scenario in the paralysed patient, optimize ventilation by using firstly the two handed ventilation technique and/or the cLMA. If those techniques fail one must resort to invasive techniques such as canula cricothyroidotomy
- Canula cricothyroidotomy requires a high pressure ventilation source with a reducing valve
- Training in these techniques is essential

Until clear simple pediatric guidelines are in place it would be reasonable to follow the general principles of the adult guidance. It is essential to get experience of the unanticipated difficult airway and to practice failed intubation drills and emergency oxygenation procedures. Training in these emergency drills should take place in every anesthetic department and can be made 'real' through the use of modern simulators.

Conclusion

The management of both the anticipated and unanticipated difficult intubation scenario in children requires forethought and training and this training should be a priority of all pediatric anesthetists.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Video Clip S1. A normal laryngoscopy, showing the excellent view obtained by the surgeon. Note the nasal airway on the posterior pharyngeal wall. If this

patient was to have laser therapy this would be withdrawn.

Video Clip S2. This video shows anaesthesia for laryngoscopy, without laser treatment, but illustrates the principles described.

Video Clip S3. The use of the Seward pediatric McCoy laryngoscope in a child.

Video Clip S4. Fiberoptic through LMA intubation using a guidewire.

Video Clip S5. Intubation of a difficult airway using hopkin's rod technique.

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Conflicts of interest

The authors have declared no conflicts of interest.

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